OROVILLE FERC RELICENSING
(PROJECT NO. 2100)

INTERIM REPORT
SP-F3.2 Task 3A

ASSESSMENT OF POTENTIAL STURGEON PASSAGE IMPEDIMENTS

REVIEW DRAFT

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1.0 SUMMARY

Three potential physical upstream migration barriers for sturgeon have been identified and were field evaluated at a representative low flow range by a team of selected sturgeon passage experts. The three potential physical upstream migration barriers included Shanghai Bench, Sunset Pumps, and Steep Riffle two miles upstream of the Thermalito Afterbay Outlet (USFWS 1995). At the evaluated river stage, Shanghai Bench is likely a sturgeon passage barrier due to the height of its waterfalls, water velocities of the mid-channel chute and lack of attraction flow to the potentially passable side-channel. At the evaluated river stage, Sunset Pumps is likely a sturgeon passage barrier due to the height of its waterfalls and water velocities of the mid-channel chute. Of the potential barriers assessed, Steep Riffle represents the most reasonably passable potential barrier and sturgeon could likely ascend the riffle without complication.

Passage determinations at each of the potential passage barriers in the lower Feather River will continue to be speculative without a greater understanding of sturgeon migration patterns, and physiologic and metabolic limitations. Final conclusions from the sturgeon passage impediment assessment will be developed and reported in August of 2003 after the "representative high flow range" observations are completed in the spring of 2003.

2.0 PURPOSE

Operations of the Oroville Facilities have the ability to affect flows within the Feather River, which may affect the ability of both green sturgeon and white sturgeon to upmigrate past potential passage barriers or impediments. This interim report satisfies the "representative low flow range of observations" to assess sturgeon passage impediments in the Feather River as defined in SP-F3.2, Task 3A. Final conclusions from the sturgeon passage impediment assessment will be developed and reported in August of 2003 after the "representative high flow range" observations are completed in the spring of 2003.

Sturgeon are neither commonly nor consistently observed in the Feather River. This portion SP-F3.2 Task 3A was designed to evaluate whether or not passage impediments to the migration of the sturgeon might contribute to the relatively low number and inconsistent observations of these fish in the Feather River. In addition to this study, sturgeon geographic and temporal distribution information will also be augmented by radio tracking, scuba surveys and creel surveys that will be conducted in the 2003 season.

The purpose of this interim report is to document and communicate the first phase of field investigation findings on representative low flow range observations of potential sturgeon passage impediments in the Feather River. Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects, including a discussion of the fish, wildlife, and botanical resources in the vicinity of the project (Code of Federal Regulations 2001). The discussion is required to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operations. As a subtask of SP-F3.2 this tasks fulfill a portion of the FERC application requirements by detailing the potential passage impediments to green sturgeon, which is a species of special regulatory status, and white sturgeon, which is a fish species of primary management concern.

In addition to fulfilling these requirements, information developed in this task may be used in developing or evaluating potential protection, mitigation and enhancement (PM&E) measures.

3.0 BACKGROUND

The study area for this task is defined in SP-F3.2 as the Feather River from the Fish Barrier Dam to the confluence with the Sacramento River (DWR 2002). Shanghai Bench, Sunset Pumps, and Steep Riffle upstream of the Thermalito Afterbay Outlet have been identified as the most likely locations for potential upstream passage impediments for adult sturgeon at low flows (USFWS 1995).

3.1 STURGEON LIFE HISTORY

Sturgeon are anadromous fish that spawn in rivers on the west coast, but spend most of their life in estuarine and marine environments, ranging geographically from southern Alaska to Mexico (Beamesderfer et al. 2002). Sturgeon are known to migrate into the Feather River, but detailed information regarding their reproduction is limited (USFWS 1995). In the mid-70s, green sturgeon were caught each year, with the majority of catches occurring from March to May and a few additional catches occurring in July and August (USFWS 1995). As recently as 1993, adult green sturgeon have been caught at the Thermalito Afterbay Outlet (USFWS 1995).

Adult green sturgeon appear to migrate upstream into freshwater beginning in the latter part of February and may continue migrating as far as 200 miles upstream before spawning (in the Sacramento River) (Beamesderfer et al. 2002). Adult white sturgeon migrate into the Sacramento River beginning in October (USFWS 1995). Although most white sturgeon spawning occurs in March and April, spawning may begin as early as February and may continue into June (USFWS 1995). Catch data indicate that most green and white sturgeon spawning in the Feather River occurs from March through May (USFWS 1995). In areas outside of the Central Valley, sturgeon spawn over rocks, compact clay substrates, or large gravels at depths of approximately 30 feet (9.1 meters) with water velocities ranging from 5-10 feet/second (1.5 - 3.0 meters/second), while Central Valley sturgeon have been observed using gravel, rubble or soft-bottom stream reaches for spawning (USFWS 1995). On the Rogue River in Oregon, holding sites were typically deeper than 16.4 feet (5 meters), with in-river residence time ranging upwards of 6 months (Grimaldo et al. 2001). Spawning locations for sturgeon in the Feather River are unknown, but it has been suggested that spawning may be limited to areas just downstream of the Thermalito Afterbay Outlet (USFWS 1995). Based on angler catch rates, spawning has been suggested to occur downstream of the Thermalito Afterbay Outlet and Gridley Bridge (USFWS 1995).

3.2 PHYSICAL PERFORMANCE PARAMETERS FOR STURGEON

Relative to salmonids, little information exists regarding sturgeon habitat preferences and swimming or leaping performance. Due to the scarcity of available data and the anticipated challenges of field data collection regarding green sturgeon, information on both the green and white sturgeon is being collected in an effort to gain a better understanding distribution and habitat preferences of both green sturgeon and white sturgeon in the lower Feather River.

Typical passage assessment methodologies rely upon physical metrics of fish performance and barrier characteristics. Fish performance characteristics utilized in passage assessments typically include burst speed, sustained speed, and leaping curves. Unfortunately, none of these fish performance metrics are currently available to quantify sturgeon swimming performance. Dr. Joseph Cech, University of California at Davis, is performing a number of experiments on sturgeon in a swimming flume to quantify sturgeon swimming performance and may have results available to incorporate into this assessment as early as Spring 2003. The results of these experiments may provide information on sturgeon burst and sustained swimming speed as well as observations of sturgeon use of velocity refuges and substrates preferences in passage assessments.

Because detailed passage criteria, such as those developed for salmonids, have not been developed for green or white sturgeon, several methods were proposed in combination to evaluate sturgeon passage for identified potential upstream migration barriers. The passage evaluation methods utilized were necessarily either subjective or exploratory due to the lack of quantitative passage information. The evaluation methods being conducted as part of the Oroville Facilities Relicensing include exploratory scuba diving surveys, creel surveys, sturgeon radio tracking and assessments of the potential passage barriers by sturgeon passage experts.

3.3 PHYSICAL BARRIER CHARACTERISTICS IN THE LOWER FEATHER RIVER

In the lower Feather River, three potential physical upstream migration barriers have been identified for sturgeon including (1) Shanghai Bench, (2) Sunset Pumps, and (3) Steep Riffle in the reach 1 to 2 miles upstream of the Thermalito Afterbay Outlet (USFWS 1995).

Three distinct potential migration barrier-types characterize Shanghai Bench. First, waterfalls approximately 3 - 5 feet (0.9 - 1.5 meters) in vertical height stretch across most of the main river channel. Second, a chute exists river-left of the main channel and contains very high velocities [e.g., > 3.3 feet/second (1 meter/second)]. Finally river-left of the waterfalls and chute, a side channel exists with much lower velocities relative to the main channel. The side channel is approximately 0.5 to 3 feet deep and captures only a very small proportion (e.g., 10%) of the total flow.

The potential migration barrier at Sunset Pumps consists of a rock dam, which spans the entire river channel. A backwater eddy is created river-left downstream of the rock dam. The dam is notched in the middle, where a very high velocity [e.g., > 3.3 feet/second (1 meters/sec)] chute has developed. Water also passes over many areas of the dam, which creates waterfalls of approximately 3 - 4 feet (0.9 - 1.2 meters) in vertical height.

Steep Riffle is a relatively high gradient riffle with intermediate water velocities [e.g., 1 - 2 ft./sec (0.3 - 0.6 meters/second)] and fairly shallow depths [e.g., <1 ft. (0.3 meters)], especially in the upstream portion.

The following section details the progress and interim conclusions of the sturgeon passage barrier expert team. Further information regarding collection of other sturgeon information, particularly the exploratory scuba diving surveys, will be reported at a later date.

4.0 METHODOLOGY

The three potential sturgeon upstream migration barriers were evaluated by a team of selected sturgeon passage experts. The sturgeon passage experts traveled to each potential upstream migration barrier on November 9, 2002. The daily average flow in the Feather River near Yuba City at the time of the assessment was approximately 2090 cfs as reported at the CDEC gaging station on the Feather River near Yuba City (http://cdec.water.ca.gov). The expert team consisted of the following representatives from various agencies and academia:

- Dr. Joseph Cech, University of California-Davis (UCD)
- Scott Lankford, University of California-Davis
- Jason Webber, University of California-Davis
- Eric Theiss, NMFS
- Michael Perrone, California DWR (DWR)
- Dave Gonzalez, California DWR
- David Olson, Surface Water Resources, Inc.
- Thomas Duster, Surface Water Resources, Inc.

While sturgeon passage assessments will be conducted at representative high flow levels in the Spring of 2003, the passage experts specifically assessed the likelihood of passage at each impediment during the observed low flow conditions. During the site visits, the expert team noted the characteristics of each passage evaluation site, and captured the sites on video and in photographs. The opinions, rationale for conclusions, and site-specific factors for consideration described by each passage expert team member were also documented. Due to the lack of quantified parameters regarding the physiologic and metabolic characteristics of sturgeon, the expert team relied mainly on their best professional judgment when considering the likelihood of passage at each barrier. To the extent possible, the team also attempted to characterize the substrate at the potential passage barriers and estimate whether the substrate was sufficient to allow sturgeon to "walk" or "scootch" up the potential barrier during low flow. However, because sturgeon preferences for substrate for these purposes in not currently known or characterized and due to safety considerations at each passage evaluation site, a detailed substrate characterization was not conducted.

In addition to the passage assessment at each potential barrier, the expert team offered numerous ideas regarding experimental design options to further evaluate the migration ability and behavior of sturgeon in the lower Feather River. These ideas were documented, and will be utilized in the design of future sturgeon investigations, including the proposed sturgeon radio tracking studies.

5.0 RESULTS

5.1 SHANGHAI BENCH

The passage expert team evaluated three distinct potential migration barrier-types existing at Shanghai Bench, including a set of waterfalls, a high-velocity chute, and a side channel (**Figure 1**). The passage expert team concluded that green sturgeon do not likely have the leaping ability to jump over the waterfalls (each approximately 3 - 5 feet (0.9 - 1.5 meters) in height) that span

most of the main river channel, and therefore the falls likely represent a vertical height migration barrier. It was also concluded that green sturgeon do not likely have the swimming ability to swim or "scootch" up the high-velocity chute. However, some members of the team postulated that there might be small pockets of passable water velocities created by substrate within or along the margins of the chute. In addition, even if areas of appropriate velocities are present at the Shanghai Bench chute, it is unknown whether a green sturgeon would choose to enter an area of such highly volatile and dynamic flow.

Figure 1. Aerial photograph of Shanghai Bench (taken June 2002).

Finally, because information regarding the mechanisms of attraction for green sturgeon is limited, the passage team could not conclude whether the side channel carries a sufficient quantity or relative proportion of the flow to attract migrating green sturgeon. The side channel is also very shallow [e.g., <0.5 ft. (0.15 meters)] in many locations, which could create a migration barrier for green sturgeon; however, the extent of this particular consideration is unknown (**Figure 2**).

In general, the expert team concluded that Shanghai Bench is likely a passage barrier at the evaluated river stage. However, further information regarding potential sturgeon use of low water depth paths, substrate for "perching or scootching," low velocity margins of potential passage opportunities and migration attraction flow requirements would be needed to definitively determine the likelihood of passage at Shanghai Bench.

Figure 2. The lower Feather River downstream of Shanghai Bench where the side channel reconnects with the main river.

5.2 SUNSET PUMPS

The passage team evaluated two potential migration barrier-types existing at the Sunset Pumps location including a high velocity chute and the waterfalls which frame it (**Figure 3**). While there was interest in gathering information regarding the substrate roughness and water column velocities of the chute, preliminary team consensus illustrated that sturgeon do not likely have the swimming ability to swim or "scootch" up the chute. However, some members of the team postulated that there might be small pockets of passable velocities within or along the margins of the chute. In addition, the expert team concluded that at the observed flow levels, green sturgeons do not likely have the leaping ability to jump over the waterfalls which cascade over the rock dam at Sunset Pumps. It is therefore likely that the waterfalls represent a vertical height migration barrier. Various members of the expert team theorized that at higher flow levels the waterfalls might become passable. During these conditions, the elevation of the downstream pool would be raised and the substrate roughness of the submerged rock dam may create pockets of passable velocities along the channel margins. This site will be reevaluated at higher flows in the spring of 2003.

In general, the expert team concluded that the Sunset Pumps location is likely a passage barrier at the evaluated representative low flow river stage. However, further investigation regarding the substrate of the river channel and the micro-velocities existing adjacent to the high-velocity chute as well as definitive information on the swimming performance and velocity refuge use and preferences of sturgeon would be needed to definitively determine the likelihood of passage at Sunset Pumps.

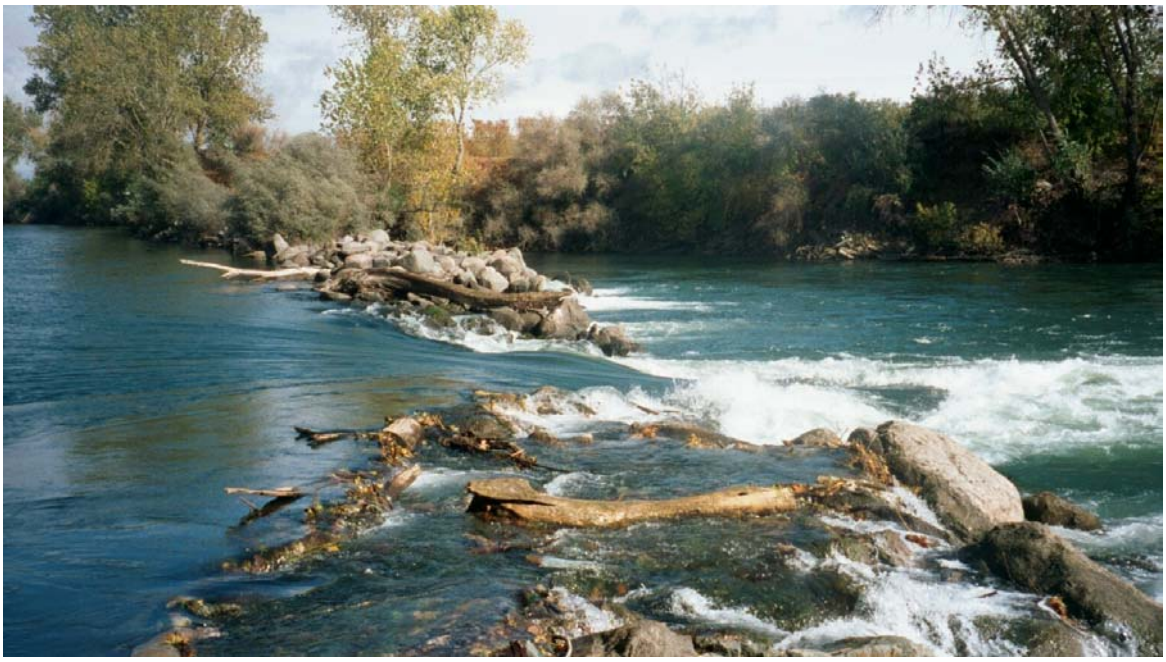

Figure 3. The lower Feather River at Sunset Pumps.

5.3 STEEP RIFFLE

The passage team evaluated Steep Riffle for potential migration barrier-types. The passage team concluded that of the potential barriers assessed, Steep Riffle represents the most reasonably passable potential barrier for green sturgeon. While the relatively shallow depths of the channel create potential passage concerns and do merit further evaluation, it was determined that green sturgeon should be able to ascend the riffle without complication. The riffle was observed at a flow of 600 cfs, which is representative and typical in this flow-regulated reach (**Figure 4**). The expert team concluded that Steep Riffle should not be included in further passage investigations.

Figure 4. The lower Feather River at the upstream end of Steep Riffle.

5.4 EXPERT TEAM RESEARCH SUGGESTIONS

The expert team believes that passage determinations at each of the potential passage barriers will continue to be speculative without a greater understanding of sturgeon migration patterns, and physiologic and metabolic limitations. Upon consideration of the abiotic and biotic characteristics of each potential passage barrier, the expert team provided a number of research suggestions which, in conjunction with a greater understanding of the geomorphologic characteristics of each site (e.g., exact waterfall heights, substrate descriptions, water velocity profiles, etc.), would be useful in determining the migratory ability and behavior of sturgeon in the lower Feather River.

Tracking studies would greatly enhance the ability to understand movement patterns and habitat preferences of sturgeon throughout the Feather River. The studies could utilize sturgeon caught by anglers, or UCD may be able to provide wild-caught fish for release after their future laboratory studies, upon regulatory agency approval. The tracking studies could identify passage barriers in the Feather River by pinpointing the upstream migratory extent or locations of significant delay of the tagged migrating fish (when considered in conjunction with abiotic and biotic factors). It is also possible to develop a tracking methodology that could identify the exact migration route. For instance, at Shanghai Bench where flows in the side channel need to be evaluated for their suitability to attract a migrating sturgeon, tracking stations could be appropriately positioned to determine whether the sturgeon utilize the secondary channel migration route. This information, combined with other tracking conclusions, would contribute considerable knowledge to the understanding of sturgeon in the Feather River and elsewhere.

The variables that represent the most important factors when considering sturgeon passage are height of falls, depth of water, water velocity, and substrate. UCD will soon (January 2003) begin lab experimentation to determine the manner in which these factors affect sturgeon migration. Each of these variables will be controlled in lab flumes to assess sturgeon swimming ability, substrate preferences, and other performance and preference characteristics. The result of the lab studies can then be applied to the future field passage assessments (e.g., Feather River sturgeon passage assessments). It is important to note that lab results regarding any aspect of sturgeon migration may not apply directly to wild fish, as the tests will be conducted in straight flumes rather than the complex habitat and hydraulic diversity of a large river. The lab results will then need to be validated with field programs.

5.5 GENERAL COMMENTS BY THE EXPERT TEAM

During the passage barrier assessment, the following comments were captured regarding sturgeon life history and migration characteristics:

Life History and Habitat Requirements

- Sturgeon likely hold in deep holes
- Sturgeon likely spawn in high-velocity, turbid riffles.
- Proper sturgeon spawning substrate likely consists of large boulders, cobbles, or possibly even riprap.
- Sturgeon would likely be present in the Feather River in January, February, and March.

Swimming Speeds

- Definitions
  - Sustained cruising speed are continued indefinitely if given unlimited energy
  - Burst speeds can be continued for approximately 5-6 minutes
- Laboratory-raised green sturgeon exhibit sustained cruising speeds of approximately 0.75 body length/second. Interpolating these results for wild-raised and reared sturgeon, the sustained cruising speed would likely approximate one body length/second. Burst speeds are undoubtedly greater, but are currently unknown.

Leaping Ability

- Sturgeons have relatively poor leaping ability. For instance, at fish ladders in the Pacific Northwest, tens of thousands of salmon and thousands of lampreys pass the fish ladders annually, while only 5 to 10 sturgeons are able to pass due to their leaping limitation.

Attraction Flow Requirements

- Very little is known about sturgeon attraction flow and channel selection requirements. However, the following are anecdotal observations:
  - Sturgeon ascend the Yolo Bypass on the Sacramento River, where a relatively small proportion of main channel flow exists
  - At Ishi Pishi Falls on the Klamath River, sturgeon have been observed attempting to ascend many possible passage routes until finding an appropriate path
  - Local fishing guides report that a flow of 5,000 cfs (142 m^3/sec) is required at Verona to attract sturgeon into the Feather River

6.0 CONCLUSIONS

The following conclusions were documented during the implementation and analysis of the sturgeon upstream migration passage barrier assessment for the lower Feather River.

1. Passage determinations at each of the potential passage barriers in the lower Feather River will continue to be speculative without a greater understanding of green sturgeon migration patterns, and physiologic and metabolic limitations;
2. At the evaluated river stage, Shanghai Bench is likely a green sturgeon passage barrier due to the height of its waterfalls, water velocities of the mid-channel chute, and lack of attraction flow to the potentially passable side-channel;
3. At the evaluated river stage, Sunset Pumps is likely a green sturgeon passage barrier due to the height of its waterfalls and water velocities of the mid-channel chute;
4. Of the potential barriers assessed, Steep Riffle represents the most reasonably passable potential barrier and green sturgeon could likely ascend the riffle without complication;
5. Tracking studies would greatly enhance the ability to understand movement patterns and habitat preferences of green sturgeon throughout the Feather River; and
6. The variables that represent the most important factors when considering sturgeon passage are likely height of falls, depth of water, water velocity, and substrate, all of which will be evaluated in a UCD laboratory beginning in January 2003.

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